netlognews

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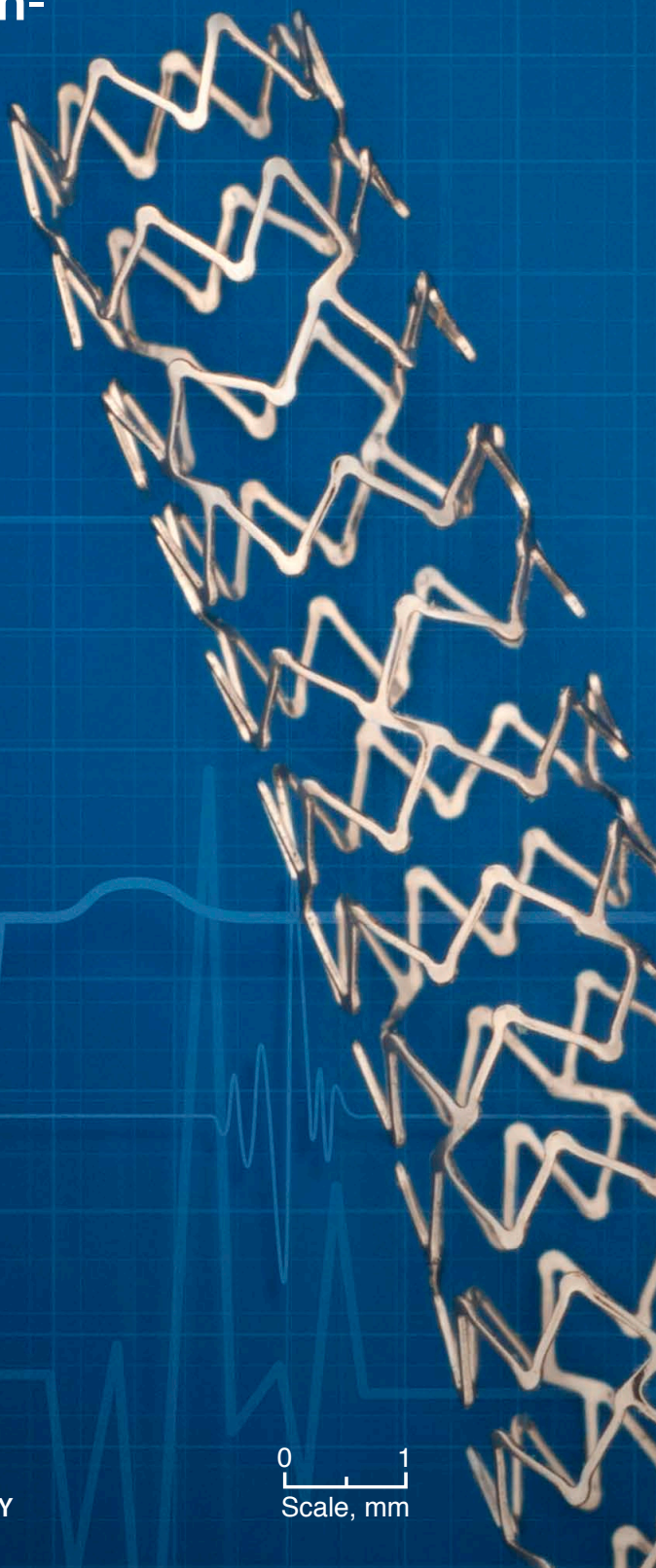

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Cover image: Boston Scientific Corporation (BSC) PROMUS ™ series coronary stent utilizing NETL/BSC-developed platinum chromium alloy.

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newlognews is a quarterly newsletter highlighting recent achievements and ongoing research at NETL. Any comments or suggestions, please contact Paula Turner at paula.turner@netl.doe.gov or call 541-967-5966.

Ice formations in the Trough Creek ice mine.

NETL Studies Ecology of Cold Air Traps in Temperate Climates—Recent studies have shown that cold air traps in temperate climates often harbor flora and fauna usually only found in far colder climates. These unusual sites of low temperature create unique "bio-geographical islands." The function and fate of these islands may serve as valuable indicators of current and future global climate change.

The first scientific report on cold air traps in eastern North America was published in the 1890s. Climatologist Edwin S. Balch visited 33 unusually cold sites, including ravines and gorges, taluses and boulder heaps, as well as man-made wells, mines and tunnels where ice had been reported to persist into the summer months. Although many cold traps were believed by local residents to "make ice" (which they used to make ice cream and cold drinks) in the summer, Balch demonstrated that most summertime ice was formed when cold air stored during the winter in rock slopes and caves froze water from snow melt and spring rain, producing ice that lasted for several months in protected environments.

As a result of an NETL investigation that began in 2009, a cold talus slope near Spruce Creek in Huntingdon County, PA, was found to harbor numerous boreal (subarctic) lichens not found elsewhere in Pennsylvania. Lichens are symbiotic associations of fungi and algae that result in hardy plantlike organisms that require few nutrients to survive. Ice formations in rock vents at Spruce Creek can persist well into early summer, and the cold air flowing out of the bottom of the rock slope during the summer allows the lichens and other

boreal plants to survive. Many other small or microscopic species undoubtedly exist here as well. Boreal mites have been shown to be biological indicators of similar cold habitats in Europe, for example. As a result of NETL scientists' efforts, more than ten lichen species previously unknown in Pennsylvania were identified at the Spruce Creek site.

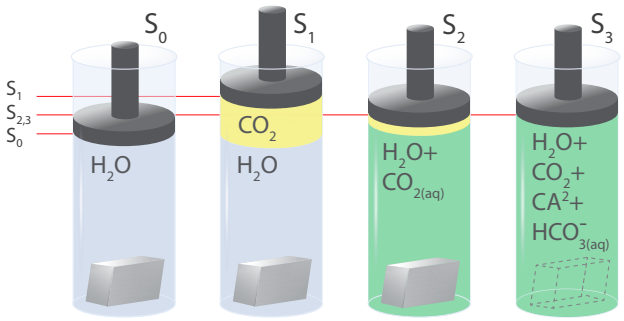
In collaboration with West Virginia University, NETL researchers also monitored the temperature in the Trough Creek ice mine, another well-known cold site in central Pennsylvania. Here the temperature inside a talus cave was recorded on an hourly basis for three years using temperature data logging sensors. NETL scientists found that the cave is isolated from the external environment and does not

Ice stalagmites at Spruce Creek talus slope in Pennsylvania.

provide a cooling effect on the environment outside the cave. Instead, the microscopic organisms within the cold cave may be more significant. Psychrophilic, or cold-loving, bacteria with an optimal growth temperature <50°F were found to be abundant inside the cave, consistent with the cool temperatures maintained within the cave year-round. The study was recently published in the peer-reviewed journal *Permafrost and Periglacial Processes.*

NETL research on the characteristics of regional cold sites and their ecology led to an invitation from the National Park Service to help evaluate the proposed designation of the Ice Mountain Preserve in Hampshire Co., WV, as the newest site in its National Natural Landmark program. Future research may show that these unique sites serve as sensitive indicators of subtle changes in temperature rise associated with global climate change.

Contact: Hank Edenborn, 412-386-6539



CO_2 Injection in Geologic Formations Article Featured as Editor's Choice in *Science*

—Carbon dioxide capture and long-term storage in confined geologic formations is one way to mitigate and defer global warming. Primary targets for that storage include porous/permeable carbonate and sandstone formations saturated with highly saline brines. Using thermodynamic modeling, researchers of the NETL/Regional University Alliance explore what happens to CO_2 when injected as a supercritical fluid into deep saline formations, in order to estimate the available storage volume.

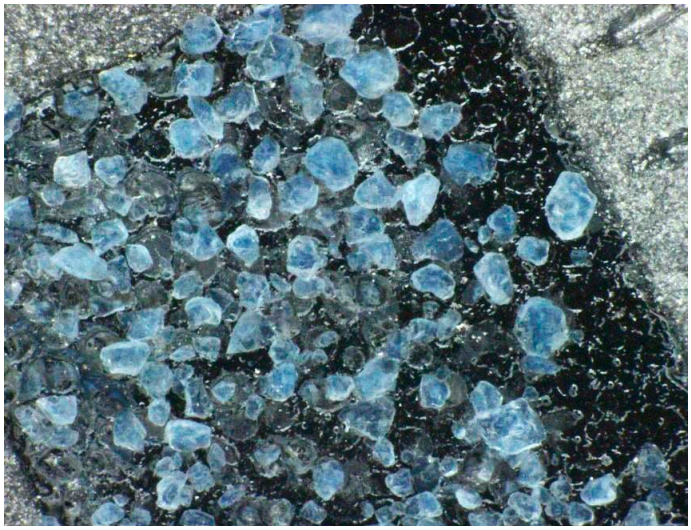
Pore space in deep saline formations would initially be filled with brine, and no "free" volume is available to accommodate injected CO_2. CO_2 will be injected by increasing formation pressure, compressing fluid and rock, and/or displacing brine. Whereas natural subsurface accumulations of CO_2 in environments similar to those proposed for CCS formed slowly and equilibrated with their surroundings over long periods, captured CO_2 will be injected at high rates of volume over a much shorter period of tens of years.

Initially, injected CO_2 will displace brine away from the point of injection but, over time, that CO_2 will dissolve in the brine. Thermodynamic analysis showed that this dissolution would yield the most favorable storage conditions and would markedly reduce storage volume requirements. It will also increase the density of the brine, helping to ameliorate leakage risk associated with storage of buoyant free-phase CO_2

The full article, selected as Editor's Choice for that edition, is entitled "Volumetrics of CO_2 Storage in Deep Saline Formations" and is available in *Environmental Science and Technology*.

Contacts: Angela Goodman, 412-386-4962, Robert Dilmore, 412-386-5763, and George Guthrie, 412-386-6571, Robert Bodnar (Virgina Tech.)

Parametric field testing of ADA-ES 1 kW pilot carbon dioxide capture reactor at Martin Lake, TX electric generation station.



BIAS sorbents.

NETL Carbon Capture Sorbents Support U.S. Energy Independence—

Carbon dioxide (CO_2) is considered one of the major greenhouse gases affecting climate change. An estimated one-third of anthropogenic CO_2 emissions to the atmosphere results from the combustion of fossil fuels used for electricity generation. One technique for preventing CO_2 emissions from entering the atmosphere is to capture and concentrate it for beneficial reuse or permanent storage in a geologic formation underground.

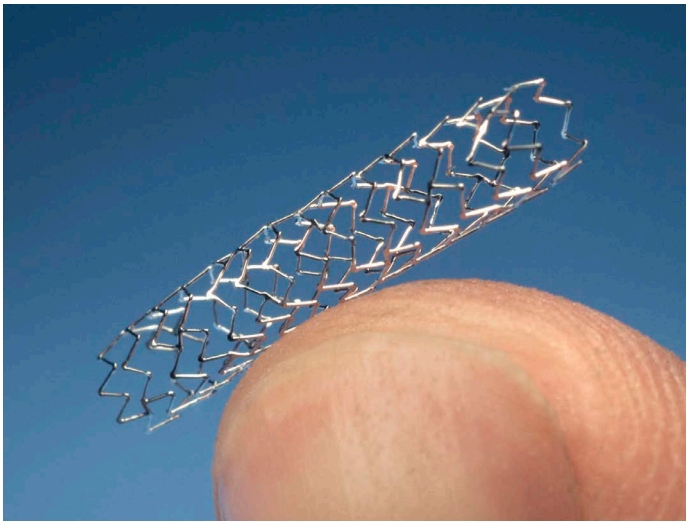
CO_2 capture and separation can be achieved by using solvents, cryogenic techniques, membranes, or solid sorbents. Large-scale operation of any of these technologies is energy intensive when applied to capturing CO_2 from the combustion stream or flue gas, where it accounts for only about 15 percent of the volume. While wet scrubbing systems using regenerable, amine-based solvents are the most commercially advanced, they are extremely energy intensive due in part to the large amount of processing water involved.

The NETL Basic Immobilized Amine Sorbent (BIAS) process is a "dry" sorbent-based CO_2 capture technology that is both technically and economically viable for removing CO_2 at low concentration from flue gas streams. The technology uses a sorbent made from an amine synthesized for high carbon dioxide selectivity and polymerized around a high surface area silica gel for ease of handling. The amine releases adsorbed carbon dioxide when heated at steam temperatures and can then be reconditioned as a solvent with no need for water.

Independent laboratory testing of over 100 sorbents demonstrated that NETL BIAS sorbents had the best overall performance. BIAS sorbents showed the greatest working capacity, a measure of the net ability of the sorbent to absorb CO_2, were readily regenerated by heating and had among the lowest projected regeneration energies—the amount of energy necessary to desorb CO_2 from the sorbents.

An initial systems analysis indicates that solid sorbents, such as BIAS sorbents, could adsorb CO_2 over a range of temperatures typically encountered downstream of flue gas desulfurization units in coal-burning power plants and with their relatively low heat capacities would reduce the energy required for regeneration by 40 percent. Moreover, compared to state-of-the-art alternatives, BIAS sorbents are more thermally stable, exhibit little or no degradation, and produce less corrosion, eliminating the need for corrosion inhibitors. All these advantages combined to earn NETL BIAS sorbents a 2012 R&D 100 award, which recognizes the 100 most technologically significant products introduced into the marketplace over the past year. Members of the award-winning NETL BIAS team are: McMahan Gray, Henry Pennline, Daniel Fauth, James Hoffman, and Kevin Resnik.

Contact: McMahan Gray, 412-386-4826



NETL/Boston Scientific Corporation-Developed PtCr Alloy Used for a New Family of Stents

—Boston Scientific has announced the European market launch of the PROMUS ELEMENT™ PLUS BTK "below-the-knee" platinum chromium stent for the treatment of certain severe peripheral artery lesions in lower legs. This is a radical expansion of the PtCr alloy stents, which in the past, have only been employed in coronary applications. The disease now being successfully treated in recent trials is Critical Limb Ischemia (CLI) or severe lower leg claudication. It is a severe obstruction of the arteries, which markedly reduces blood flow to the extremities (in most cases feet and legs) and often results in limb amputation and death. The new stents, utilizing the platinum chromium alloy developed by a team of NETL and Boston Scientific scientists, have shown significantly better clinical outcomes than the previously used stents.

"The drug-eluting stent is an important additional tool that I use to address focal stenosis in the arteries below the knee, and ultimately reduced amputation rates in CLI and claudicant patients," said Martin Kamarád, M.D., of Podlesí Hospital in Trinec, Czech Republic. "In addition to the benefits of drug delivery, I believe the PROMUS ELEMENT™ PLUS BTK stent offers significant advantages in terms of properties in the design and higher resistance to compression and less recoil thanks to its unique platinum-chromium alloy and stent architecture."

Boston Scientific already has a 45 percent market share of the coronary stent market and believes that this new addition to their product line will dramatically increase this share.

The collaborators involved in developing the Pt-Cr stent alloy were recipients of an R&D 100 award last year and were recognized by the Federal Laboratory Consortium (FLC) with a 2012 Award for Excellence in Technology Transfer, and a Secretary of Energy's Honor Award in October 2012.

Contacts: Paul C. Turner, 541-990-0204 and Paul D. Jablonski, 541-967-5982

Novel Method Traces Organic Contaminant Transport in Karst Aquifers

—Hydrologic factors affecting the transport of contaminants in water coursing through underground drainage systems known as karsts, which are formed by mildly acidic water action on weakly soluble bedrock such as limestone, are not well-understood. Although soluble tracers such as dyes can be used to help understand the behavior of water-soluble pollutants, their behavior differs in less soluble contaminants lighter than water, i.e., light non-aqueous phase liquid (LNAPL) pollution.

To better model LNAPL contaminant transport in natural systems, collaborators at NETL and West Virginia University developed and tested hydrogel tracer beads made with alginic acid, a derivative of marine algae. The beads typically contain 96-98 percent water, are environmentally benign and easily made, and can be tailored for density (buoyancy), size, color, and fluorescence. Comparative tracer testing was conducted in a cave stream near Lewisburg, WV, where buoyant beads containing hollow glass microspheres were tested alongside soluble fluorescein dye.

After simultaneous release of dye and beads at the head of the test section, grab samples of stream water were collected every 20 seconds at its discharge point and analyzed for dissolved tracer by fluorometry; tracer beads were also collected every 20 seconds from the stream surface. Data showed that while solute tracers dispersed laterally and horizontally through the stream water, the buoyant beads were transported mainly in the zone of high surface velocity. The innovative beads effectively demonstrated that while LNAPLs can move rapidly through the karst section, a significant percentage can be retained, even within a relatively "trap-free" stretch of stream. Future testing will focus on a longer cave section having a greater number of traps that could impede the downstream transport of LNAPLs and floating particulates.

Contact: Harry Edenborn, 412-386-6539

At the USGS Core Library in Denver, South Dakota School of Mines and Technology geology graduate student Kelsey Marzolf samples Niobrara Shale core samples from wells located near the Rosebud Sioux Indian Reservation in South Dakota.

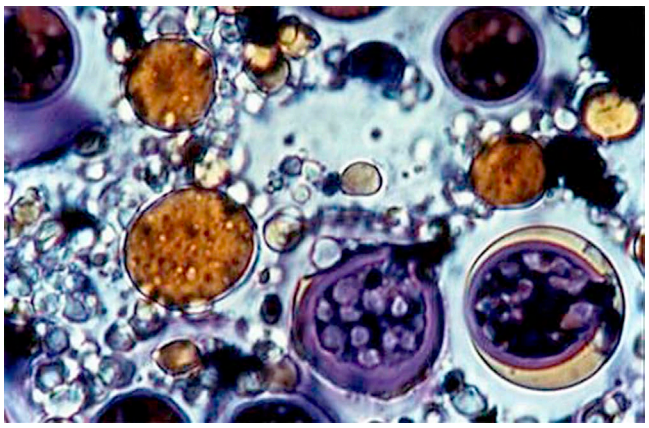
NETL Establishes a Partnership with the American Indian Higher Education Institute

—NETL is in the process of establishing a Partnership Agreement with the American Indian Higher Education Institute (AIHEI). This collaboration will allow NETL scientists to assist and train Native American geology students at tribal colleges in methods used to assess the resource potential of gas and oil shales on reservation lands. These will primarily include investigations of mineralogy, total organic carbon content, thermal maturation, oil and gas generation potential, and petrophysical properties of the rock, such as porosity (measure of amount of open space in rocks) and permeability (measure of ease of fluid moving through porous rock), which affect production. The potential environmental and water resource risks of developing shales on the reservation will also be studied.

Scientists will have the opportunity to investigate previously unassessed resources on Indian reservations, and provide an opportunity to compare hydrologic and environmental impacts on ecosystems that differ significantly from those overlying the Marcellus and Utica shales.

The initial project will focus on the hydrocarbon potential of the Niobrara shale on the Rosebud Sioux reservation in South Dakota, in cooperation with Sinte Gleska University and the South Dakota School of Mines and Technology. The Navajo Nation is also interested in assistance with evaluating the Mowry and Mancos shales in the San Juan Basin in southwestern United States.

Contact: Daniel J. Soeder, 304-285-5258



Producing Liquid Fuels Using Microalgae Reveals Potential

—Due to continuing high demand, depletion of non-renewable resources and increasing concerns about climate change, fossil fuel-derived transportation fuels face constant challenges from both a world market and an environmental perspective. Producing renewable transportation fuel from microalgae attracts much attention because of its potential for fast growth rates, high oil content, ability to grow in unconventional scenarios, and its inherent carbon neutrality.

Microalgae are microscopic, single-cell organisms that exist in fresh water and marine environments and also at the bottom of the food chain. Under optimal conditions, microalgae can be grown in massive, almost limitless, amounts. Almost half of microalgae's weight is lipid oil. Scientists have been studying this oil for decades to convert it into biodiesel—a fuel that burns cleaner and more efficiently than petroleum. Moreover, the use of microalgae would minimize "food versus fuel" concerns associated with several biomass strategies, as microalgae do not compete with food crops in the food chain.

Recent research on transportation fuels production using microalgae provides a more fundamental understanding of catalyst selection and conversion processes using computational modeling. This research shows the potential of various thermocatalytic pathways to produce alternative transportation fuels from algae, and identifies key areas where computational modeling should be directed to optimize the process. A recent article was published about this study in *RSC Advances*.

Contact: Ping Wang, 412-386-7539 and Bryan Morreale, 412-386-5929

Oxy-combustion/Integrated Pollutant Removal (IPR™) Receives European Patent

—Integrated Pollutant Removal (IPR™) is a CO_2-capture process which purifies captured flue gas, producing a flow of supercritical CO_2 ready for sequestration or further processing toward other uses. Jupiter Oxygen Corporation developed oxycombustion technology under a grant from NETL and in cooperation with NETL seeking to bring a near-zero emissions power production system to the market. NETL's IPR was tested at the Jupiter Burner Test Facility over the last several years. The research team was notified in October that U.S. Pat. 8,087,926, "Oxy-Fuel Combustion with Integrated Pollution Control," has been granted a European patent (EP 2495493). An application for the "Module-Based Oxy-Fuel Boiler" (U.S. Pat. 7,516,620) is also being reviewed by the European Patent Office. The module-based oxy-fuel boiler was invented during the work between NETL and Jupiter Oxygen as a way to take full advantage of the added radiant energy available from an oxy-fired flame to produce steam power.

The market for implementing near-zero emissions power production in Europe, including retrofit (leaving heat transfer surfaces in place), repowering (where the power-plant's boiler is replaced—leaving steam turbines in place) and greenfield scenarios, becomes more robust with the addition of these patented technologies. The added opportunities for construction of plants like these will speed the development and optimization of this approach to power production, uncovering synergies that will increase effectiveness.

Contact: Danylo Oryshchyn, 541-967-5865

Divisional Patent Issued for High Temperature NETL Alloy

—The U.S. Patent and Trademark Office has assigned Patent No. 8,317,944 to the United States of America as represented by DOE for additional embodiments of heat-treated 9 Cr-1 Mo steel material described in Patent No. 8,246,767. The invention by NETL researchers Paul D. Jablonski, David Alman, Ömer Doğan, Gordon Holcomb, and Christopher Cowen relates to a high-temperature, titanium-alloyed, 9Cr-1Mo steel exhibiting improved creep strength and oxidation resistance at service temperatures up to 650 °C.

The novel combination of composition and heat treatment produces a heat-treated material containing both large primary titanium carbides and small secondary titanium carbides. The primary titanium carbides contribute to creep strength; the secondary titanium carbides strengthen the steel by impeding the movement of dislocations through the crystal structure, and increase oxidation resistance by maintaining a higher level of chromium in the finished steel.

The heat-treated material provides improved performance at a cost comparable to that of commonly used high-temperature steels such as ASTM P91 and ASTM P92, and it requires only heat treatment consisting of austenization, rapid cooling, tempering, and final cooling, with no need for any hot-working in the austenite temperature range.

Contact: Paul Jablonski, 541-967-5982

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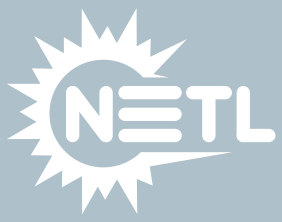
Patents Issued This Quarter

1.	9 Cr-1 Mo Steel Material for High Temperature Application. Paul D. Jablonski, David Alman, Omer Dogan, Gordon Holcomb, and Christopher Cowen, **8,317,944,** issued November 27, 2012; additional embodiments of heat-treated 9Cr-1 Mo steel material described in Patent 8,246,767.
2.	Oxy-fuel Combustion with Integrated Pollution Control., Brian R. Patrick, Thomas L. Ochs; Cathy A. Summers; Danylo B. Oryshchyn; and Paul C. Turner, **European patent EP 2495493**, issued October 2012.



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